Essays on Banking Competition and the Real Economy

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ABSTRACT

PANIT WATTANAKOON: Essays on Banking Competition and the Real Economy.
(Under the direction of Toan Phan and Gary Biglaiser)

As big banks grow larger and larger in the past decades, the banking industry become more and more concentrated. This poses questions on how bank market power affects the real economy. In this dissertation, I address such economic incidence and try to understand the effects of bank mark-up on the business cycle and economic growth.

In the first chapter, I simplify Kiyotaki and Moore (1997) into a two-period model, adds bank market power and study the amplification effects. When borrowers are forced to fire sell their assets, the asset movement from more to less productive sectors generates adverse feedback toward the economy. The existence of an imperfect banking market forges the interest spread and raises the cost of borrowing, making the fireselling agents more constrained and intensifying the recession.

In the second chapter, I study how bank size affects economic growth. The growth model with a finite number Cournot banks from Cetorelli and Peretto (2012) is simplified into that with two big and small banks. Big bank with larger equity tends to borrow less, lend more standard loan, and provide less relationship service than the small one. Nonetheless, I find that the size difference holding the total credit constant does not deteriorate the growth prospect but rather encourages big bank to lend and contribute more to economic growth due to its efficiency in providing relationship loans.

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BANKING COMPETITION AND THE AMPLIFICATION MECHANISM

1.1 Introduction

The study on how financial activities affect the real economy is extensively conducted since the Great Recession[1]. The deep and persistent slump observed in the real-world business cycle after the financial crisis attracts more researchers to study the macro-financial linkages. The applications of micro-founded financing restriction such as costly state verification (Townsend 1979), quantity rationing (Stiglitz and Weiss 1981), and incomplete contract (Hart and Moore 1994) are prevalent in the macroeconomic model.

After the onset of the 2008 financial crisis, some banks were out of the business, while some were merged together. The number of banks in the US fell by 12 percent during 2006-2010 due to both mergers and bank failures (Wheelock 2011), together with the fact that the higher concentration ratio of banks in the developed economies has been observed even before the crisis (Mundial 2012). This poses a question on how much bank market power intensifies the economic slump.

This paper simplifies Kiyotaki and Moore (1997) into two-period model, add Monti-Klein oligopolistic financial intermediaries developed in Klein (1971) and Monti (1972), and compare the amplification effects. For a competitive banking case, borrowers with a certain degree of reinvestment requirement will be forced to sell their input at a price lower than its marginal product. The relocation from more to less productive producers contracts the economy. For a oligopolistic case, bank market power contributes to a larger spread between the interest rates. A higher borrowing rate makes constrained agents more in short of resources. It distorts the agents' behavior and makes the economy more sensitive to a negative shock. Promoting banking competition alleviates

[1]See Brunnermeier, Eisenbach, and Sannikov (2013) on a comprehensive review on financial frictions, and Claessens and Kose (2017) on a recent survey of macro-financial linkages

the amplification effect.

The contribution of this paper is to study the collateral constraint in financial friction and market imperfection in industrial organizations to investigate the oligopolistic banking behavior, examine the role of market power in the macro-economy, and compare the equilibrium results in different banking market structure.

Section 1.2 outlines the model on how lenders, borrowers, and financial intermediaries interact. Section 1.3 is devoted to explaining the amplification mechanism from the lower asset demand due to consumption and collateral constraints in the economy with perfectly competitive banking market, while section 1.4 talks about the bank market power as an additional channel to intensified the recession. Section 1.5 concludes.

Related literature. This paper relates to a few strands of literature. First is the pecuniary externalities from financial friction. Krishnamurthy (2003) studies the amplification mechanism from collateral constraint due to incomplete contract[2] by stripping down the model in Kiyotaki and Moore (1997) into a finite horizon model. The main characteristics of the paper that distinguish it apart from other literature such as Bernanke, Gertler, and Gilchrist (1999) is that the aggregate capital is fixed. The amplification emerges from a lower asset demand of the constrained agent that dumps down its price and produces the adverse feedback to the economy. Nevertheless, financial intermediaries were not discussed in this work.

Many later literatures on financial friction include financial intermediaries in their analyses such as Iacoviello (2015), Sanjani (2014) and Bocola and Lorenzoni (2017) and study their interaction with the pecuniary externalities. But little attention is paid on the market power of banks on the amplification mechanism[3].

There is another strand of literature on bank market structure debating on a trade-off between

[2]When the contract is incomplete (payment in some states of the world is not clearly written), both parties will renegotiate for their own benefit. Realizing this possibility, the lender will take into account this situation when issuing the initial contract. Ex-ante funding is hardly secured. To rule this out, the collateralized contract is implemented. The repayment is then fully specified in all states of the world.

[3]For recent work on monopolistic banking, see Andrés, Arce, and Thomas (2013), and Fujiwara and Teranishi (2017).

competition and financial fragility. On the one hand, the competition-instability hypothesis (Allen and Gale 2004) argues that if all banks are price takers, in order to survive in such an environment, banks will take excessive risks and the higher probability of default is expected. Diallo (2015) used data from 145 countries to scrutinize this relationship and found that competition is not good for a sound banking system. On the other hand, the competition-stability hypothesis argues that when banks have more market power, a higher interest rate is charged to borrowing companies (Boyd and De Nicolo 2005). It induces such companies to take more risks to pay all the loans back. Then a higher possibility that firms will fall and raise the non-performing loans. Anginer, Demirguc-Kunt, and Zhu (2012) supports this view by empirically discovering that concentration are prone to greater systemic fragility.

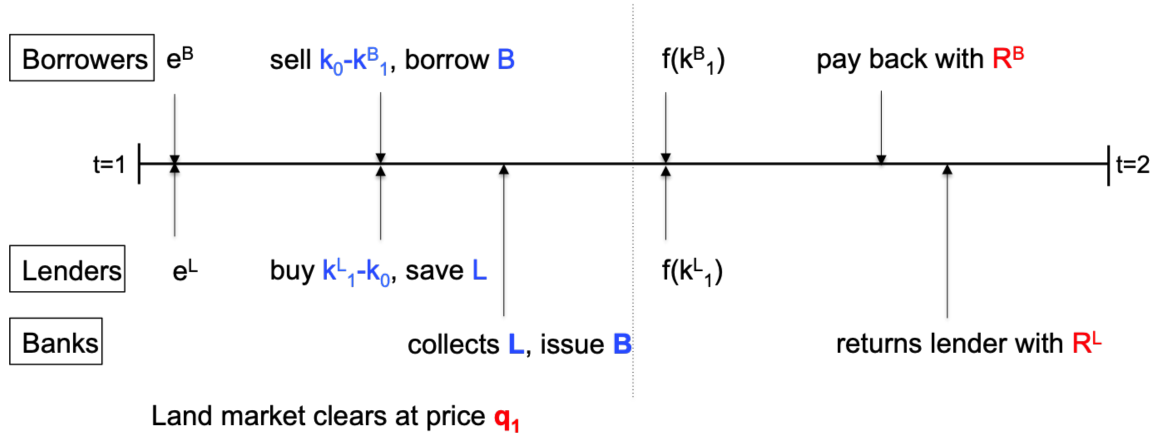
This paper is also related to Dávila and Korinek (2018) which they try to decompose the pecuniary externalities arising from financial friction. In their work, there are distributional and collateral externalities when agents do not take into account how their actions affect asset prices. A social planner could internalize those spillovers and achieve constrained efficiency. This paper talks about these pecuniary externalities and how they are affected by banking market power.

1.2 The Model

Considers a discrete-time economy with a finite horizon for t=1,2. There are 3 agents: a unit mass of lenders and borrowers, and n number of banks. Borrower and lenders have linear utility function with discount factors β^B and β^L both in $(0, 1)$, while banks only consume in the second period. Lenders own half portion of the land: $k_0 = \bar{K}/2$ and then make decisions on consumption, one-period deposit, and land purchase. Borrowers also own half of the land, then decide to consume, borrow, and purchases land for production given the collateral constraint. Both produce with the same concave production technology $f(k_1^i) = k_1^i(A - k_1^i)$ and are endowed with e^L and e^B at date 1. The borrower's endowment can be negative, which implies there is a reinvestment requirement. Figure 2.1 discuss the timeline.

All financial activities regarding borrowing and lending are only facilitated by financial intermediaries because we assume that banks are able to collect collateral directly from defaulted borrowers, while lenders cannot. Banks also need to bear some screening and monitoring costs.

Figure 1.1: Timeline



1.2.1 Main model features

Lenders' Problem The representative lender optimizes the consumption bundles he wants, the number of lands he purchases, and the amount of deposit he saves. On date 1, lender spends their expenditure on consumption c_1^L, loan to banks L, and land for the next-date production $q_1(k_1^L - k_0)$. For the revenue, he obtains his initial endowment e^L. On date 2, he consumes c_2^L from his output $f(k_1^L)$, and principle plus interest $R^L L$.

$$\max_{c_1^L, c_2^L, k_1^L, L} c_1^L + \beta^L c_2^L$$

subject to

$$c_1^L + L + q_1(k_1^L - k_0) \leq e^L \tag{1.2.1}$$

$$c_2^L \leq f(k_1^L) + R^L L \tag{1.2.2}$$

$$c_1^L \geq 0 \tag{1.2.3}$$

$$c_2^L \geq 0 \tag{1.2.4}$$

$$k_1^L \geq 0 \tag{1.2.5}$$

where R^L is the rates of return he gets back after depositing into the banks. q_1 is a land price at date 1. We can find the first-order necessary conditions:

$$q_1 = \beta^L f'(k_1^L) \tag{1.2.6}$$

$$\beta^L R^L = 1 \tag{1.2.7}$$

From equation 1.2.6, the price of land in the first period is determined by its marginal product. Equation 1.2.7 indicates that the marginal benefit from saving is equal to the marginal cost of this period consumption forgone.

Borrowers' Problem The representative borrower faces similar inter-temporal problem to lender but the collateral constraint. On date 1, his revenue comes from his endowment e^B, borrowing made to the bank B limited to the collateral constraint and a portion of capital gain from selling land $q_1(k_0 - k_1^B)$, while his expenditure is for consumption c_1^B. Date 2 budget constraint is similar to lenders except that borrowers need to repay their debt $R^B B$.

$$\max_{c_1^B, c_2^B, k_1^B, B} c_1^B + \beta^B c_2^B$$

subject to

$$c_1^B \leq e^B + q_1(k_0 - k_1^B) + B \tag{1.2.8}$$

$$c_2^B + R^B B \leq f(k_1^B) \tag{1.2.9}$$

$$R^B B \leq \theta f(k_1^B) \tag{1.2.10}$$

$$c_1^B \geq 0 \tag{1.2.11}$$

$$c_2^B \geq 0 \tag{1.2.12}$$

$$k_1^B \geq 0 \tag{1.2.13}$$

In contrast with the lender's optimization problem, the borrower's decision to borrow is restrained by a fraction θ of output, ranged between 0 and 1. This θ measures the degree of credit friction when $\theta \to 0$ means no transactions in credit market via bank, while $\theta \to 1$ reflects perfect credit market. His debt payment cannot exceed the output he can produce. This is because when the debt is due, the output is used for repayment instead.

The solution can be derived from setting up Kuhn-Tucker conditions and solving for an optimal quantity of land demanded as well as borrowing. Given that $f'(0) \geq R^B q_1$ or the marginal product of land at $k_1^B = 0$ being higher than its land price discounted with R^B, the borrower will always obtain fund from the banks and sacrifice their date-1 consumption since the productivity is higher than what they need to pay back.

Banks' Problem We follow the simplified version of banking firm introduced by Klein (1971) and Monti (1972)[4]. When banks are engaged in deposit and loan, the optimization problem for a financial intermediary is similar to that of a firm. The profit is derived from the revenue net cost. Assume that lending and borrowing are only conducted via financial intermediaries due to their ability to obtain collateral from borrowers. In this section, we consider two different types of banking structures which are perfectly competitive and oligopolistic markets.

Perfectly competitive banks face the following maximization problem:

$$\max_{B,L} \pi = R^B B - R^L L - C(B)$$

subject to

$$B = (1 - \alpha)L$$

Banks obtain funds from lenders L and issue them out to borrower B. The compulsory reserve $\alpha \in [0, 1]$, which is controlled by the policymaker, requires banks not to lend all of their deposit. Assume that bank has a linear cost of loan provision: $C(B) = \gamma \cdot B$. First-order necessary

[4]For a textbook version of the model, see Freixas and Rochet (2008)

conditions are:

$$R^B = \frac{R^L}{1-\alpha} + C'(B) \tag{1.2.14}$$

Equation 1.2.14 shows that the marginal benefit from lending to borrower is equal to the marginal cost of paying interest rate back to depositor and its management cost. For one unit of loan to the borrower, banks need to find $\frac{1}{1-\alpha}$ unit of deposit to lend out. In the following part, we consider the oligopolistic financial intermediaries' problem.

Monti-Klein oligopolistic banks: Suppose that n financial intermediaries with the same cost structure have access to the interbank market. With the market power to set interest rate, each financial intermediary i faces the following problem:

$$\max_{B_i, L_i} \pi_i = R^B(B)B_i - R^L L_i - C(B_i)$$

subject to

$$B = \sum_{j=1}^{n} B_j = B_i + \sum_{i \neq j} B_j$$
$$B_i = (1-\alpha)L_i$$

For simplicity, assume that each individual oligopolistic financial intermediary has market power over the loan market and not on deposit. An individual financial intermediary can control only its own supply of credit, and choose the optimum amount of loan issued to customers by taking into account other bankers' strategies, which affects the borrowing rate of the whole market. Given the same cost structure, we assume a symmetric equilibrium, in which each sets $B_i = \frac{B}{n}$, $L_i = \frac{L}{n}$. We can find first-order necessary conditions:

$$R^B + B_i \frac{\partial R^B}{\partial B} \frac{\partial B}{\partial B_i} \frac{\partial B_i}{\partial L_i} = \frac{R^L}{1-\alpha} + C'(B) \tag{1.2.15}$$

For equation 1.2.15, the first term of the left-hand side is the marginal benefit of an additional loan provided, and the second term is the revenue generated from bank market power that it can extract from credit demand. The right-hand side is similar to a perfect competitive case. We can rearrange the first-order necessary condition with respect to loan as a price net cost divided by a price (the Lerner's index), which is equal to the inverse interest elasticity in equation 1.2.16. Note that the interest elasticity of borrowing follows: $\epsilon = \frac{\partial B}{\partial R^B} \cdot \frac{R^B}{B}$ and when the number of banks approaches infinity, we have the same first-order necessary conditions: $R^B = \frac{R^L}{1-\alpha} + C'(B_i)$ as that in perfectly competitive case.

$$\frac{R^B - \left(\frac{R^L}{1-\alpha} + C'(B_i)\right)}{R^B} = -\frac{1}{n\epsilon} \tag{1.2.16}$$

1.2.2 Equilibrium

Since we have two different banking market structures, we define two different equilibria:

A competitive equilibrium with perfectly competitive banks: is the allocation of quantities and prices as following: $\{c_1^B, c_2^B, c_1^L, c_2^L, \pi, k_1^L, k_1^B, B, L, R^B, R^L, q_1\}$ that satisfy lenders' optimal conditions, borrowers' optimal conditions, collateral constraint, financial intermediaries' optimal conditions, market clearing condition $\bar{K} = k_1^B + k_1^L$.

A symmetric equilibrium with oligopolistic banks: in which all banks set the same borrowing rate R^B, and maintain the same quantity of loans and deposits ($B_i = \frac{B}{n}$ and $D_{1,i}^L = \frac{L}{n}$ for $i = 1, 2, \ldots, n$) is an allocation $\{c_1^B, c_2^B, c_1^L, c_2^L, \pi_i, k_1^L, k_1^B\}$ and prices $\{R^L, q_1\}$ that solves lenders', borrowers', and financial intermediaries' maximization problems, and all market clearing condition $\bar{K} = k_1^B + k_1^L$.

1.3 The Amplification with Competitive Banks

In this section, we discuss the equilibrium for land market by putting together demand and supply for land at date 1 and explore the amplification mechanism. The demand and supply are determined by the borrower's and lender's optimal conditions. We will start our analysis on the perfect market and study the market power in section 1.4.

1.3.1 Equilibrium in land market

From borrower's perspective, lenders are land supplier. Optimization condition of lenders yields the upward sloping supply of land in price at date 1, which takes the form:

$$\mathcal{K}_s(q_1) = \bar{K} - f'^{-1}(\frac{q_1}{\beta^L}) = \bar{K} + \frac{1}{2}\Big(\frac{q_1}{\beta^L} - A\Big) \tag{1.3.1}$$

for $\beta^L(A - 2\bar{K}) < q_1 < \beta^L A$; otherwise, the solution is at the corner where either lender or borrower owns all the land. If the land price is too high $\beta^L(A - 2\bar{K})$ or twice of its marginal product at $k_1^L = \bar{K}$, lenders do not want to buy it and if it is too low $\beta^L A$ or its marginal product at $k_1^L = 0$, they will purchase all of it.

For land demand, consider the date-1 optimization problem for borrowers. If date-1 consumption and collateral constraints (equation 1.2.11 and 1.2.9) are not binding, we obtain equation 1.3.2 as an unconstrained borrower's demand for land, which is downward sloping given the concave production function.

$$k_1^{Bu} = f'^{-1}\Big(\frac{q_1}{\beta^B}\Big) = \frac{1}{2}\Big(A - \frac{q_1}{\beta^B}\Big) \tag{1.3.2}$$

When the marginal product of land is higher than its discounted price: $f'(0) \geq R^B q_1$, date-1 consumption constraint binds. The borrower had better sacrifice date-1 consumption to buy more land for date-2 production and consumption. The constrained borrower's demand for land can be expressed as equation 1.3.3.

$$k_1^{Bc} = k_0 + \frac{e^B + B}{q_1} \tag{1.3.3}$$

If the land price in the first period is high enough and makes date-1 consumption constraint not binding, the borrower will have more ability to purchase both this period consumption and land for next-period production. Therefore, the borrower's demand for land is given by the minimum of the constrained and unconstrained demands, expressed in equation 1.3.4.

$$\mathcal{K}_d(q_1, R^B) = \min\{k_1^{Bu}, k_1^{Bc}\} = \min\left\{\frac{1}{2}\Big(A - \frac{q_1}{\beta^B}\Big), k_0 + \frac{e^B + B}{q_1}\right\} \tag{1.3.4}$$

Consider the effect of price on the constrained demand for land. If the borrowers are forced to sell their initial land, the higher the land price is, the less land they need to sell (thus demand more land), the positive relationship between land demand and price is formed, formalized in proposition 1.3.1, then the constrained borrower's demand for land is increasing[5] in q_1, when the price of land is lower than a threshold $\hat{q}_1$ and greater than $\bar{q}_1$. We will focus on the firesold case.

Proposition 1.3.1 1. If $e^B \leq e^*$, borrower's date-1 consumption and collateral constraints are binding.

2. If $\hat{e}_1 \leq e^B \leq \hat{e}_2$, then we have upward sloping borrower's demand for land and borrowers fire sells their land

Proof See appendix A.1.

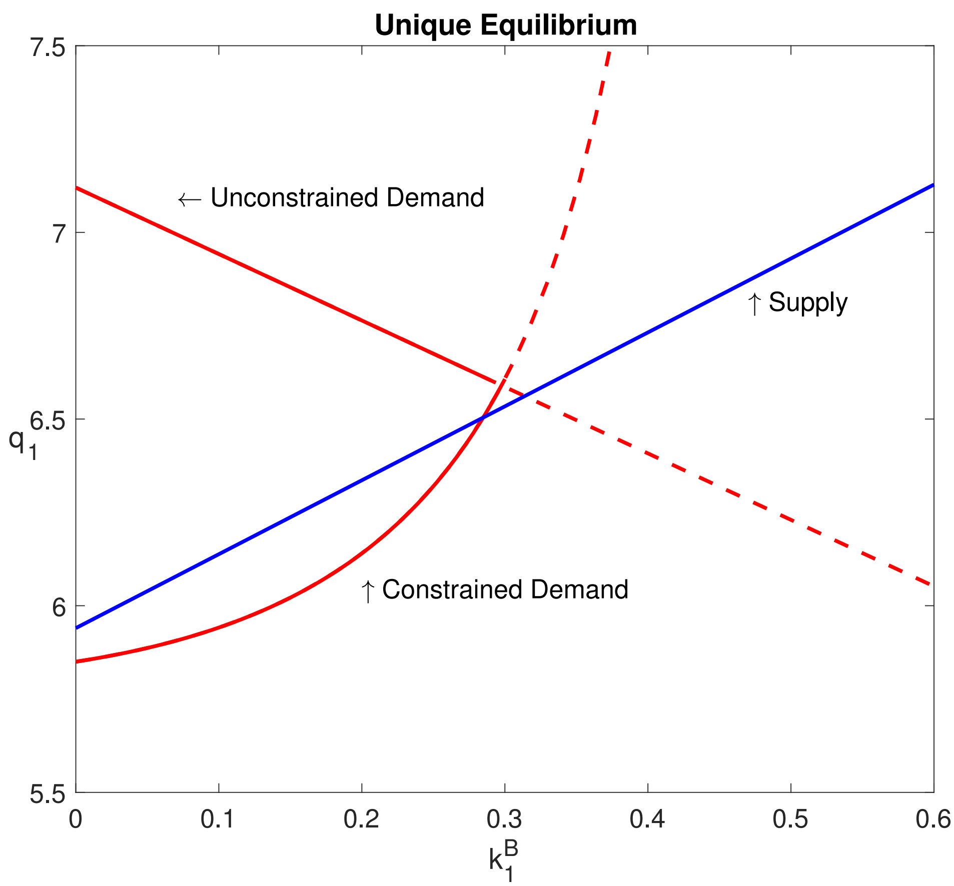
When we combine borrower's demand and lender's supply for land to derive the equilibrium price of land q_1. Figure 1.2 shows the numerical result of the unconstrained and constrained demands and supply for land in t=1, given perfectly competitive banking market. When borrowers are not constrained, the demand for land is downward sloping. Nevertheless, when the borrower is constrained, the demand for land is instead upward sloping. We then have a kink borrower's demand for land. The constrained equilibrium quantity of borrower's demand for land is lower than the unconstrained case due to the amplification effect.

1.3.2 The mechanism

The upward-sloping demand for land in equation 1.3.4 is the source of amplification mechanism if borrowers are required to sell their land from proposition 1.3.1. There are two channels from net worth and collateral constraints. The first one is: When the borrower is required to reinvest, his net worth falls and needs fire sell the land to cover that up. The firesold land will be traded at a lower price than its marginal product; otherwise lender will not purchase it. That will drive down the land price q_1 and reduce the borrower's demand for land $\mathcal{K}_d$. The second channel is through the collateral constraint. The falls in net worth and borrower's demand for land will also

[5] Dusansky and Koç (2007) provides empirical evidence on upward sloping housing demand to its price since housing is also considered as an investment asset, which its effect dominates its role as consumption goods. In our paper, the land also acts as an investment as there is a capital gain from holding it across times.

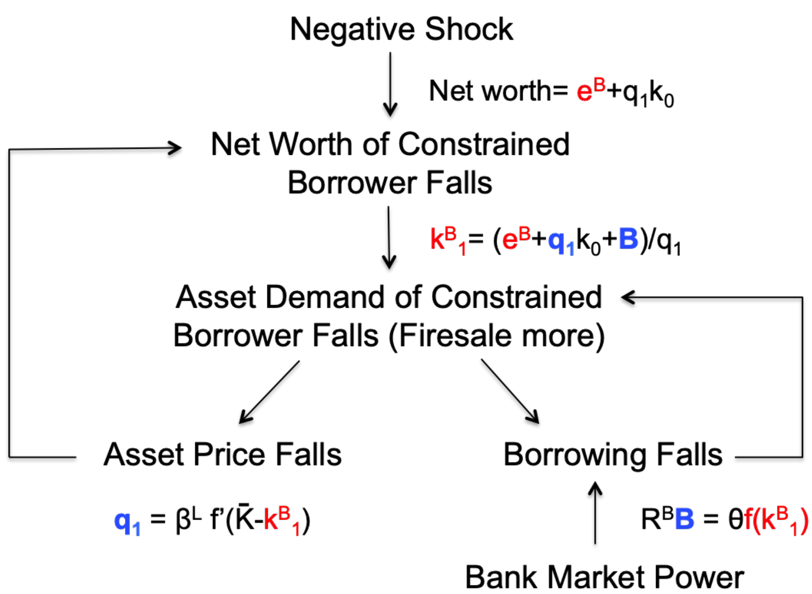
Figure 1.2: Equilibrium in Land Market



Note: Parameters used for numerical computation are: $\beta^L = 0.99, \beta^B = 0.89, \bar{K} = 1, k_0 = 0.5, A = 8, e^B = -2.95, \theta = 0.78, \alpha = 0.1, \gamma = 0.0013$

cause a fall in collateral value. Borrowers will be able to borrow less and lower his demand for land. This amplifies the output contraction further. Figure 1.3 summarizes the idea.

Figure 1.3: Amplification Mechanism

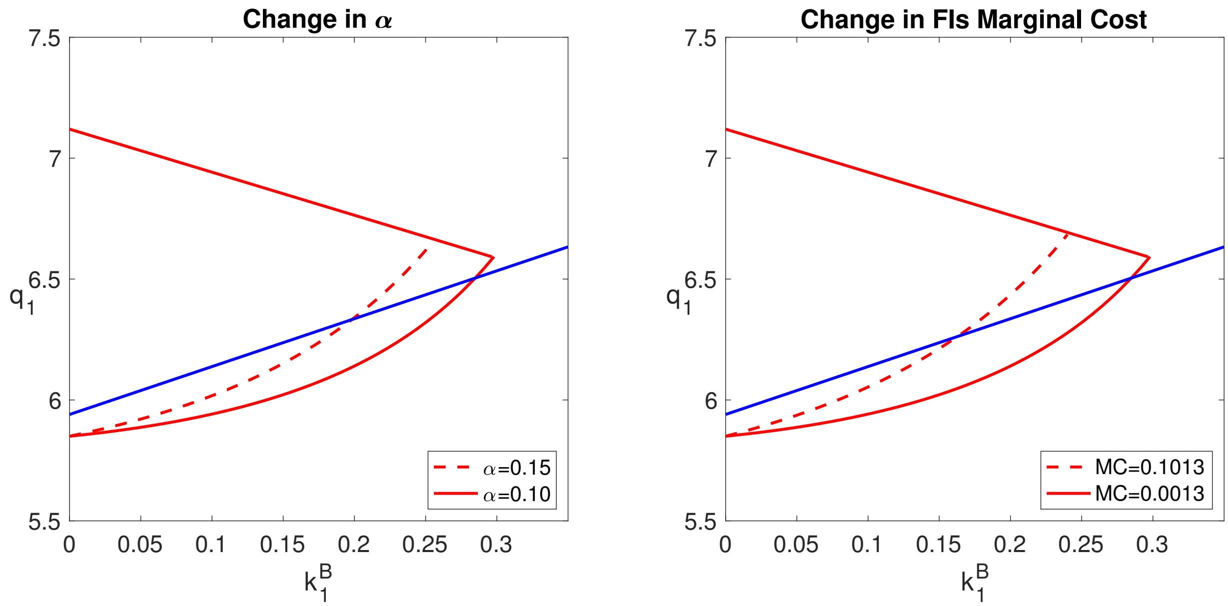


Note: Modified from Kiyotaki and Moore (1997)

We conduct the comparative statics for the perfectly competitive case to find a tool policymaker can employ to stimulate the economy. The left panel of figure 1.4 shows that when central bank lowers the compulsory reserve (α) of the financial intermediaries from 0.15 to 0.1 resulting in a right shift in the borrowers' land demand, banks will lend more as they have no need to keep a larger portion of their portfolio in their vault. More credit is provided to borrowers, and the economy is stimulated.

Better technology in banking can help. This includes a policy tool to reduce costs of screening and monitoring. Figure 1.4 (right panel) suggests that when financial intermediaries can lower marginal cost for loan provision, the spread falls and borrowers are able to obtain more credit. The dashed line of borrower's land demand shifts to the right. Thus, the economy will not go into that much deep recession.

Figure 1.4: Monetary Policy and Marginal Cost of Banking



1.4 Bank Market Power

We analyze the amplification in an oligopolistic case. The different market structure for financial intermediaries delivers different borrowing rates, which results in a different allocation of loan.

1.4.1 Equilibrium in land market with the mark up

Supply for land is derived from lenders' problem which is not directly affected by the change in the interest rate on borrowers, only indirectly through the change in land demand from borrowers. Both constrained and unconstrained borrower's demand for land still follows equation 1.3.4. We will now focus on how the interest rate on borrowing is related to borrower's demand for land.

Proposition 1.4.1 If borrower's net worth and collateral constraints are binding, then $\mathcal{K}_d$ is decreasing in R^B, and $R^{B,PC} < R^{B,O}$.

Proof See appendix A.2.

From proposition 1.4.1, we find that the borrower's demand for land is decreasing in the loan rate. When the cost of debt is increasing, the borrower will find it harder to pay the loan back.

A smaller amount of borrowing means that the borrower cannot afford to buy more land to produce. As a consequence, borrowers demand less land. Another result we can derive from proposition 1.4.1 is that the equilibrium borrowing rates in the oligopolistic case are larger then that in the perfectly competitive one. The oligopolistic bank has market power to manipulate the amount of loan issued to a borrower. In order to maximize profit, the oligopolistic firms can extract some of the borrowers' surplus in the credit market by forging higher spread than perfectly competitive financial intermediaries. They will lend less for higher loan rate and lower borrower's demand for land as a result.

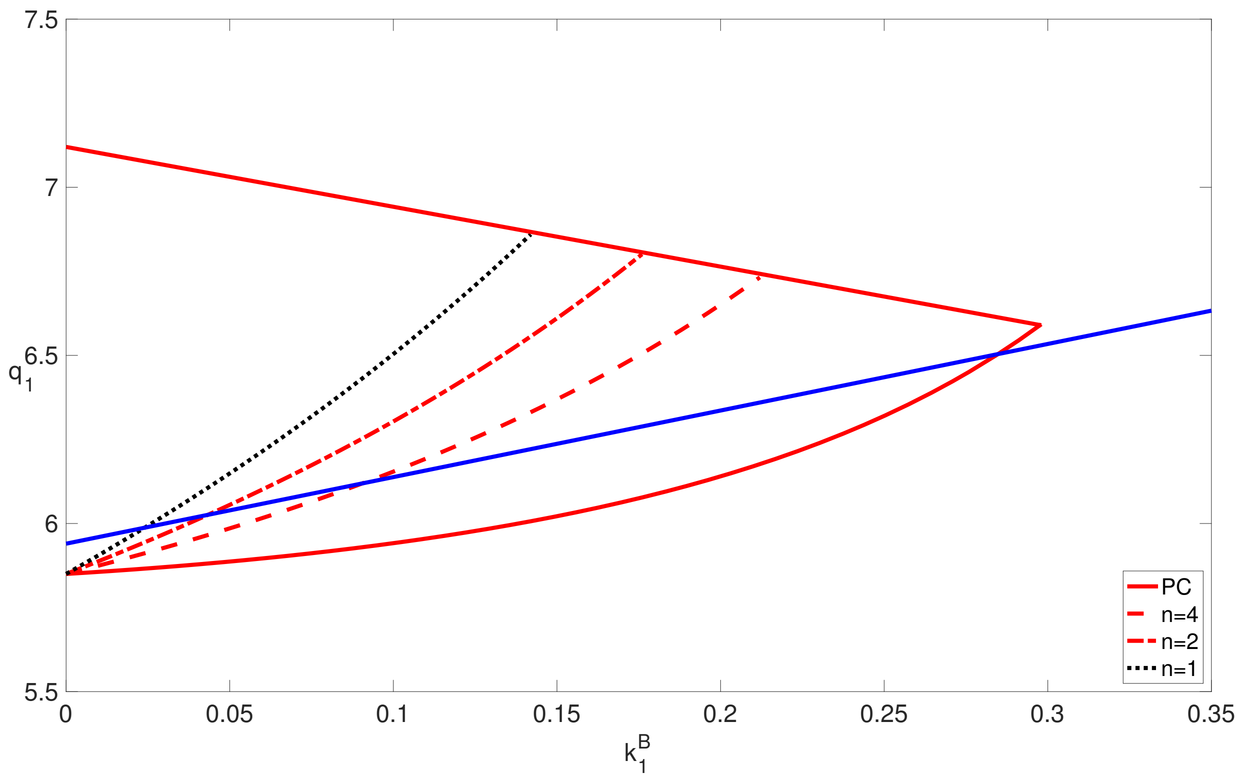
Consider the date-1 equilibrium in land market. A higher borrowing interest rate charged by oligopolistic banks leads to lower equilibrium borrower's demand for land. Figure 1.5 illustrates the equilibrium in land market when the credit market is operated by a few banks. The increasing part of borrower's demand for land shifts to the left, compared to the perfectly competitive case. The fall in output is larger when the banking market structure is not perfect. More banks make equilibrium borrower's demand for land for both cases higher, and the demand curve approaches that of perfect competition.

For a monopolistic case, the bank can completely manipulate the total supply of borrowing and influence the borrower's demand for land and its price. Since the monopoly lends less and charges higher a borrowing rate, borrowers have less incentive to borrow to purchase land. When comparing the equilibrium borrower's demand for land in perfectly competitive, oligopolistic, and monopolistic banking markets, the monopolistic-equilibrium borrower's demand for land is the smallest than that in other market structures.

1.4.2 The mechanism with the mark up

A higher borrowing rate in the oligopolistic market and its negative relationship with borrower's demand for land contribute to a lower level of borrower's demand for land $k_1^{B,O}$, compared with $k_1^{B,PC}$. We can conclude that the economy with oligopolistic financial intermediaries is more sensitive to a negative shock than the economy with perfectly competitive financial intermediaries.This is because k_1^B is decreasing in R^B, then given the same shock, larger R^B from market power makes k_1^B smaller. Moreover, given that the constrained borrower holds a lower level of

Figure 1.5: Land Market with Competitive, Oligopolistic, and Monopolistic Banks



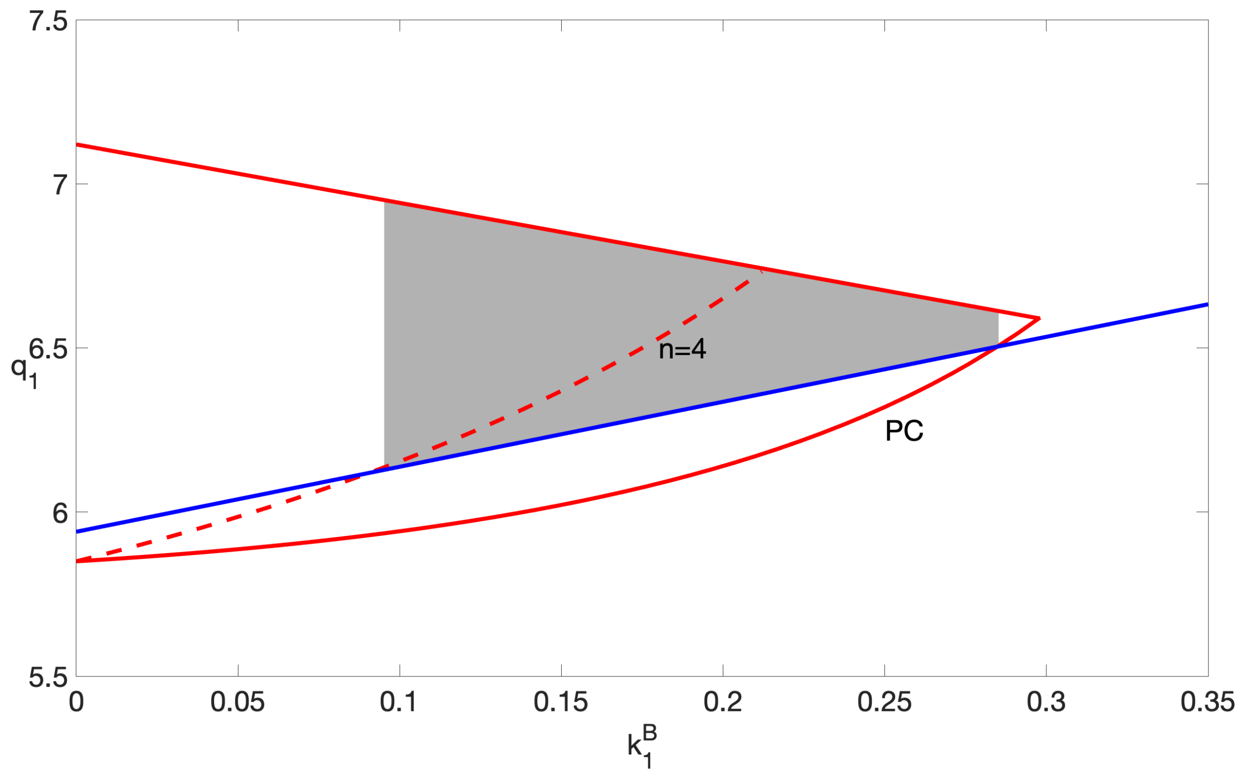
Note: Parameters used for numerical computation are the same as in figure 1.2.

land, he is more productive than the lender because of the concave production function. The output slump is magnified by an asset movement from more to less productive sectors due to the constrained borrower and the imperfect credit market. Proposition 1.4.2 formalizes the idea.

Proposition 1.4.2 Given $k_1^{B,PC} > k_1^{B,O}$, equilibrium output in perfectly competitive banking market is larger than that in oligopolistic case: $y_1^{PC} > y_1^O$

Proof See appendix A.3.

Figure 1.6: Output loss



Note: Parameters used for numerical computation are the same as in figure 1.2.

Figure 1.6 helps visualize proposition 1.4.2. Since the demand curves are derived from the marginal product of land, the area under the curve, which is the integral of marginal product of input and input, indicates the amount of output produced by borrowers and lenders. The area difference between the perfect competition and the oligopoly is shaded and tells us about the output loss from bank market power.

To avoid a severe contraction in borrower's demand for land and output when banks have market power, the central bank can employ a traditional monetary policy to help reduce the cost of funding and loosen the constrained borrowers' budget to demand more land as a result.

1.5 Conclusion

The amplification mechanism stems from the lower asset demand that drives down its price and generates adverse feedback toward the economy. Without financial intermediaries, the amplification mechanism is smaller in magnitude. Given the managerial cost of financial intermediaries, the interest gap is materialized as a result.

With oligopolistic banks, the amplification effect is larger since the borrowing rate is marked up by the market power. The economy with oligopolistic banks is then more sensitive to a shock than that with perfectly competitive ones because banks with market power capture the surplus from other agents. Banking competition should then be encouraged so that the amplification effect is dampened after the shock.

CHAPTER 2

BANK SIZE AND ECONOMIC GROWTH

2.1 Introduction

The banking industry has become more and more concentrated. Federal Deposit Insurance Corporation (FDIC) reports that there were over 10,000 commercial banks in 1984, but fell to under 5,000 in 2016. After the 2008 economic crisis, McCord and Prescott (2014) found that the biggest slump of the number of banks is due to the smallest size class, which is those with less than $100 million in assets and that two-thirds of such drop are attributed to the lack of entry. Incidentally, the US economy expands at a lower rate compared with pre-crisis trend. Many inquiries are conducted to investigate the relationship between banking market structure and economic growth.

The relationship between banking competition and economic growth is theoretically and empirically ambiguous. Many studies support the view that the more perfectly competitive the banking market is, the better the credit market functions since the loan rate will be kept at a competitive rate and support growth (Black and Strahan 2002, Smith 1998, Guzman 2000). On the other hand, many literature argues that banks with market power have more incentive to screen and monitor their clients, and issue more loans, fostering economic growth (Petersen and Rajan 1995, Cetorelli and Gambera 2001, Zarutskie 2006). Nonetheless, some researches suggest that such a relationship is not straightforward and depends on the characteristics of the economy (Deidda and Fattouh 2005, Cetorelli and Peretto 2012).

Given how concentrated the banking market has become, bank size is another prospect we could model banking competition. Berger and Dick (2007) found that there is an early-mover advantage in the service industry of banking, using data between 1972 to 2002. Banks that enter markets early enjoy larger market shares. Large banks often secure innovation before fringe banks, for example, in credit scoring (Akhavein, Frame, and White 2005), securitization (Minton, Sanders, and Strahan 2004), and internet banking (Furst, Lang, and Nolle 2002). With better technology, empirical evidence suggests that bigger banks have lower average cost. Corbae and D'Erasmo (2014) also modeled dominant and fringe banks' interaction and investigates how a change in capital requirement contributes to a change in the banking market structure.

The strategic advantage or disadvantage between large and small banks is not new in the banking industry. Davila and Walther (2017) discussed how bank size affects bailout policy. In their model, large banks influence how much taxpayer's fund is spent since the government will concern about its size due to a too-big-too-fail story that might create systemic risks.

In Cetorelli and Peretto (2012), Cournot banks provide two types of loans for entrepreneurs: relationship and standard loans. The relationship services guarantee that the credits are successfully transformed into capital for production, while the standard loans are lent to investment projects with some degree of failure. They found that when the economy has intrinsic market uncertainty, less competition leads to more capital accumulation because banks with market power will have more incentive to provide relationship loans and facilitate entrepreneurs' investment projects.

Nonetheless, there are different sizes of banks out there in the real economy. The size differences might have some implication on economic growth. Thus, Cetorelli and Peretto's model could be extended to incorporate banks' type. This paper aims to study how the banking market structure with big and small banks affects capital accumulation. We find that the differences in size foster growth. When the efficient banks becomes larger, they can afford to lend more of both standard and relationship loans and contribute to higher level of total output.

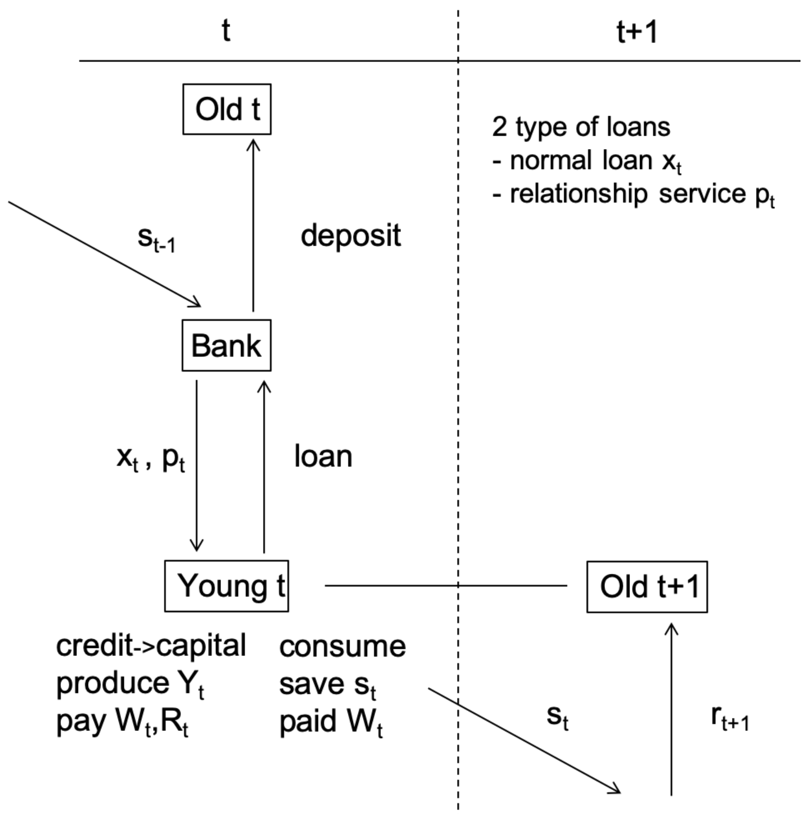
The paper organizes as following. The next section outlines the model, how households, entrepreneurs, and banks behave, and how credit is transformed into capital. Section 3 characterizes the equilibrium, while section 4 talks about aggregate capital accumulation. Section 5 concludes.

2.2 The model

We study the economy with an infinite horizon. Overlapping generation household and firm's setups follows Cetorelli and Peretto (2012), but two banks of banks: big and small. Young household works, consumes and saves s_t for their consumption when old, while firms pay young household W_t as wage and produce output Y_t.

Banks are born with an endowment e^i: $e^b = e_0 + \delta$ for big bank and $e^s = e_0 - \delta$ for small bank where $e_0 > \delta$. Banks obtain deposits S_t from young households and lend firms $X_t + 2e_0$ amount of credit. Apart from a standard credit issuance, they lend a portion of credit p^i as relationship loan. We can think of such a loan as a liquidity insurance against any mishap which can happen in an investment project. By extending relationship loans, banks incur a cost β, and the provision of this particular type of loan can raise the likelihood of success of the project. A special characteristic of this loan is that it can be free ridden and will be discussed more in the later subsection. Both households and firms have no preference for any particular type of bank.

Figure 2.1: Timeline



Timing. Figure 2.1 sums up the timeline of the model. At date t, the young work in firms, save wages in banks and consumes. Firms receive credit X_t from banks. If they succeed in transforming credit into capital, capital stock K_t and labor L_t are used to produce final goods Y_t, which will be bought by the old and paid back, not only the interest to banks but also wages to young households.

Banks return the deposit plus interest to savers at date t+1.

2.2.1 Household

Consider a unit mass of household who lives for two periods and has no population growth. The young have no capital endowed, but only one unit of labor, while the old use only the saving left after work in the period before. Assume that young household supplies labor inelastically $L_t = 1$. Household optimizes:

$$\max_{c_t, c_{t+1}, s_t} U(c_t, c_{t+1}) = c_t^\alpha + c_{t+1}^\alpha, \text{ where } \alpha < 1 \tag{2.2.1}$$

subject to

$$c_t = W_t - s_t$$
$$c_{t+1} = s_t r_{t+1}$$

Let c_t and c_{t+1} be consumption in young and old, respectively. Household decides to save s_t at date t and obtain wage W_t from work. They receive saving plus interest back when old at a rate, r_{t+1}. Solving the above problem yields equation 2.2.2, which is the upward-sloping supply for saving for banks.

$$r_{t+1}(S_t; W_t) = \left(\frac{S_t}{W_t - S_t}\right)^{\frac{1-\alpha}{\alpha}} \tag{2.2.2}$$

2.2.2 Firm

There exists a representative firm producing homogenous final goods for the economy. Suppose its technology satisfies a standard neoclassical production function and Inada conditions.

$$Y_t = F(K_t, L_t) = AK_t^\gamma L_t^{1-\gamma}, \text{ where } 0 < \gamma < 1 \tag{2.2.3}$$

Producer optimizes according to the following demand for capital and labor equations:

$$R_t = f'(K_t) = \gamma A K_t^{\gamma-1} \tag{2.2.4}$$

$$W_t = f(K_t) + K_t f'(K_t) = (1-\gamma) A K_t^{\gamma} \tag{2.2.5}$$

Prices of both capital and labor depend on their respective marginal products. Firms will hire young labor with wage W_t and obtain credit with loan rate R_t before transforming it into capital. We talk about such technology in the next section.

2.2.3 Capital and Credit

Capital. Entrepreneurs have no endowment and need to borrow from banks in order to invest it into capital. That is, a unit mass of entrepreneur $i \in [0, 1]$ borrows credit from bank and converts it into capital with linear transformation technology:

$$K_{it} = \vartheta_i X_{it} \tag{2.2.6}$$

where ϑ_i is a random variable, i.i.d. across time and across entrepreneurs, which takes value one with probability θ and zero with probability $1-\theta$ and X_{it} is the total credit obtained by an individual entrepreneur i at time t. Each entrepreneur succeeds with probability less than one, and if he fails, the expected liquidation value is zero. Assume that ϑ_i is size invariant for simplicity.

Credit. Banks can engage with all borrowers at any optimal scale since they can collect more savings from the working young if they are short of credit to lend. There are two types of services banks can provide. The first one is the standard loan that a firm will face uncertainty around their investment project. The second type of loan is relationship services that is assumed to facilitate entrepreneurs to succeed in their investment activities.

The relationship loan can be thought of as a contingent liquidity line for entrepreneurs to borrow in case of an emergency. A mismatch of inflows and outflows of firms' financial obligation could potentially disrupt a successful project. By providing such services, it costs banks β unit of output, but it helps dissipate the uncertainty according to the random variable ϑ_i. Therefore, firms with a relationship loan from a bank will successfully invest credit into capital with probability one. There are some literatures discussing about bank liquidity services and better firms' performances (James 1987, James and Wier 1987, Lummer and McConnell 1989, Hoshi, Kashyap, and Scharfstein 1991, Gatev and Strahan 2006, Shockley and Thakor 1997, and more recently Li and Ongena 2015)

Free riding feature. An essential feature of the model is the spillover of relationship service that might incentivize other banks to free ride. If at least one bank offers a relationship loan, all uncertainty for that entrepreneurs disappears. Other banks will want to issue standard loan to that particular entrepreneur without incurring relationship costs. There are literature in favor of this setup. Ongena, Roşcovan, Song, and Werker (2014) found that bank loan announcement affects bond spread issued by that particular firm, which is an evidence to support our claim that credit commitment provides less risky investment perceived by others.

One might argue that banks will want to offer an exclusive relationship contract and hinder a firm from other banks. But there is no incentive for entrepreneurs to stick with the contract since there is also another bank out there to borrow, and they can keep borrowing up to their expected profit without relationship loan. Although banks can threaten firm to withdraw a relationship contract, firms will find it hard to believe because relationship loans raise the likelihood of success and the expected profit. Walking away from the contract only hurts banks' revenue. Evidences in Detragiache, Garella, and Guiso (2000), Ongena and Smith (2000), Gopalan, Udell, and Yerramilli (2011), and Presbitero and Zazzaro (2011) suggest that firms borrow from more than one banks to diversify their sources of fund and/or reduce liquidity risks.

In our model, a bank decides how much they lend to firms either with or without additional services to accommodate the success of an investment project, taking into account that the other financial intermediary acts simultaneously on the same population of borrowers. We study how the interaction between big and small banks about their loan and relationship services affects the capital accumulation process and thus economic growth.

2.2.4 Bank

Suppose that there are two banks: big and small ones. Both banks collect deposits from the young and issue standard and relationship loans to entrepreneurs. Big and small bank will obtain endowment $e^b = e_0 + \delta$ and $e^s = e_0 - \delta$, respectively[1]. They both have market power and compete in Cournot type of setting.

Big Bank Ignoring the time subscript without loss of generality, for Big bank, its expected profit from issuing to an entrepreneur i a loan of size $x_i^b + e_i^b$ is[2]

$$\pi_i^b = \underbrace{p^b\Big(R(x_i^b + e_i^b) - \beta\Big)}_{\text{issues relationship}} + \underbrace{(1-p^b)(1-p^s)\theta R(x_i^b + e_i^b)}_{\text{not issue relationship and neither does other}} + \underbrace{(1-p^b)(p^s)R(x_i^b + e_i^b)}_{\text{not issue but the other issues rel}} - r x_i^s$$

Define p^b and p^s as the probability that big and small banks offer relationship loans, respectively, since they move simultaneously and employ mixed strategy. β is the cost of a relationship loan. R is the loan rate from producer optimization problem, whereas r is the deposit rate from households' optimization problem.

The above equation indicates the profit of a small bank from both issuing or not issuing relationship loan to entrepreneur i. The first term tells the net profit from providing the relationship services. The second term gives the expected profit if none of the relationship loans are given by any other banks, which is why there is a probability θ attached. The third term is the free-riding profit if at least one bank relates to entrepreneur i. The fourth is the interest paid back to the old.

We can then aggregate over the mass of applicants $i \in [0, 1]$. Define $x_i^b = \int_0^1 x_i^b di$, $e^b = \int_0^1 e_i^b di$.

[1] We have e_0 to make sure that a change in δ affects only the size difference δ not the total capital of the economy.

[2] Assume that banks need to issue credits to all entrepreneurs. We rule out a possible profitable deviation in which a bank decides to double the amount of credits x and lower relationship p twice to keep the same level of revenue and reduce its cost.

Rearrange the equation:

$$\begin{aligned}\pi^b =& \int_0^1 p^b\Big(R(x_i^b+e_i^b)-\beta\Big)di + \int_0^1 (1-p^b)(1-p^s)\theta R(x_i^b+e_i^b)di \\ &+ \int_0^1 (1-p^b)(p^s)R(x_i^b+e_i^b)di - \int_0^1 rx_i^b di \\ =&\Big\{1-(1-\theta)(1-p^b)(1-p^s)\Big\}R(x^b+e^b) - rx^b - p^b\beta\end{aligned}$$

Given how banks give standard and relationship loans to entrepreneurs, we can derive the total capital from the summation of relationship credit and the expected amount of standard credit.

$$K = \Big(x^{b,rel}+\theta x^{b,nor}\Big) + \Big(x^{s,rel}+\theta x^{s,nor}\Big)$$

We can sum successfully transformed credit by both big and small banks and the expected value of standard credits by both banks as:

$$\begin{aligned}K &= \Big\{1-(1-\theta)(1-p^b)(1-p^s)\Big\}x^b + \Big\{1-(1-\theta)(1-p^b)(1-p^s)\Big\}x^s \\ &= \Big[1-(1-\theta)(1-p^b)(1-p^s)\Big]X \\ &= mX\end{aligned}$$

where

$$m = 1-(1-\theta)(1-p^b)(1-p^s) \tag{2.2.7}$$

Denote X and m as total credit and credit efficiency. This credit efficiency demonstrates how successfully the economy can transform credit to capital. If either type of banks decides to lend out more relationship loan, the credit efficiency of the whole economy will increase and so does the total amount of capital. We can rewrite big bank's optimization problem as in equation 2.2.8. They choose the amount of credit and relationship services to maximize their profit.

$$\max_{x^b,p^b} \pi^b = \Big[m\cdot R(mX) - r(X)\Big]x^b - p^b\beta \tag{2.2.8}$$

Small Bank Apart from being endowed with a smaller amount of endowment, the small bank has a similar objective function. Its expected profit is

$$\max_{x^s,p^s} \pi^s = \Big[m \cdot R(mX) - r(X)\Big]x^s - p^s\beta \tag{2.2.9}$$

The equation 2.2.9 gives us the optimization problem of small banks where the first term gives the net profit of return from both relationship and standard loans. The second is the cost for relationship services. We will next discuss their decisions on credit issued and relationship services provided.

Banks' optimal choices To find an optimal choice of banks in credit issuing, we differentiate equation 2.2.8 with respect to x^b, we obtain equation 2.2.10, which implies that the marginal benefit from borrowing including how much it can influence the demand for loans is equal to the marginal cost from paying back its source of fund.

$$mR + (x^b + e_0 + \delta)m\frac{\partial R}{\partial x^b} = r + x^b\frac{\partial r}{\partial x^b} \tag{2.2.10}$$

The equation 2.2.10 can be rewritten as 2.2.11 and indicates that the spread between loan and deposit rate depends on the inverse of credit efficiency m. As the economy becomes more and more efficient in transforming credit into capital, firms will have more productive capital at hand, and their marginal product in capital will fall, leading to a decrease in loan rate. The second term in equation 2.2.11 tells us about the market power of big bank: the nominator is for deposits, while the denominator is for loans.

$$\frac{R}{r} = \frac{1}{m}\left[\frac{1 + \frac{x^b}{X}\frac{1}{\epsilon_r}}{1 + \frac{x^b+e_0+\delta}{X+2e_0}\frac{1}{\epsilon_R}}\right] \tag{2.2.11}$$

where the interest elasticities of deposit and loan are expressed as following

$$\epsilon_r = \frac{\partial X}{\partial r}\frac{r}{X} = \frac{\alpha}{1-\alpha}\frac{W-X}{W}$$
$$\epsilon_R = \frac{\partial X + 2e_0}{\partial R}\frac{R}{X+2e_0} = -\frac{1}{1-\gamma}$$

For relationship services, consider big bank's optimal decision. We differentiate equation 2.2.8 with respect to p^b yields equation 2.2.12

$$p^b = \begin{cases} 0 & \text{if } x^b\left[R + m\frac{\partial R}{\partial K}X\right]\frac{\partial m}{\partial p^b} < \beta \\ (0,1) & \text{if } x^b\left[R + m\frac{\partial R}{\partial K}X\right]\frac{\partial m}{\partial p^b} = \beta \\ 1 & \text{if } x^b\left[R + m\frac{\partial R}{\partial K}X\right]\frac{\partial m}{\partial p^b} > \beta \end{cases} \tag{2.2.12}$$

For $p^b \in (0,1)$,

$$\beta = \underbrace{(x^b + e_o + \delta)}_{\text{credit issued}} \cdot \underbrace{R}_{\substack{\text{interest rate}\\\text{on relationship}\\\text{loan}}} \cdot \underbrace{(1 + \frac{1}{\epsilon_R})}_{\substack{\text{contribution to}\\\text{capital via}\\\text{contribution to}\\\text{credit efficiency}}} \underbrace{\left[(1-\theta)(1-p^s)\right]}_{\substack{\text{contribution to}\\\text{aggregate probability}\\\text{of relationship loan}}} \tag{2.2.13}$$

Equation 2.2.12 narrates the big bank's decision on relationship loan. If the marginal cost of relationship β is higher than its marginal benefit, there is no incentive for big bank to engage in relationship services, and vice versa. Banks are indifferent and will choose any portion of credits for relationship loans when the marginal cost and benefit are equal, following equation 2.2.13. More relationship services will increase the aggregate probability of success in credit transformation and raise the amount of total capital. Those capital returns will come back to big bank as an interest payment in a proportion of credit issued.

For small bank's optimal choice, we have the following:

$$\frac{R}{r} = \frac{1}{m}\left[\frac{1+\frac{x^s}{X}\frac{1}{\epsilon_r}}{1+\frac{x^s+e_o-\delta}{X+2e_o}\frac{1}{\epsilon_R}}\right] \tag{2.2.14}$$

$$\beta = (x^s+e_o-\delta)\cdot R\cdot(1+\frac{1}{\epsilon_R})\Big[(1-\theta)(1-p^b)\Big] \tag{2.2.15}$$

2.3 The banking sector's equilibrium

Big and small banks obtain a different amount of endowment. We can think of the big bank as having larger equity than the small one. This difference in size will have an impact on how they choose their optimal actions against the counterparty. We have the following equations to characterize the equilibrium for capital and credit efficiency.

$$1-(1-\theta)(1-p^b)(1-p^s) = \left\{\frac{X^{1-\gamma}\Big(\frac{W}{W-X}\Big)^{\frac{1-\alpha}{\alpha}}\Big(1+\frac{(1-\alpha)W}{\alpha(W-X)}\frac{x^b}{X}\Big)}{A\gamma(1-(1-\gamma)\frac{x^b+e_o+\delta}{X+2e_o})}\right\}^{\frac{1}{\gamma}} \tag{2.3.1}$$

$$1-(1-\theta)(1-p^b)(1-p^s) = \left\{\frac{X^{1-\gamma}\Big(\frac{W}{W-X}\Big)^{\frac{1-\alpha}{\alpha}}\Big(1+\frac{(1-\alpha)W}{\alpha(W-X)}\frac{x^s}{X}\Big)}{A\gamma(1-(1-\gamma)\frac{x^s+e_o-\delta}{X+2e_o})}\right\}^{\frac{1}{\gamma}} \tag{2.3.2}$$

$$\frac{x^b+e_o+\delta}{(X+2e_o)^{1-\gamma}} = \frac{\beta}{\gamma^2 A}\frac{\Big\{1-(1-\theta)(1-p^b)(1-p^s)\Big\}^{1-\gamma}}{(1-\theta)(1-p^s)} \tag{2.3.3}$$

$$\frac{x^s+e_o-\delta}{(X+2e_o)^{1-\gamma}} = \frac{\beta}{\gamma^2 A}\frac{\Big\{1-(1-\theta)(1-p^b)(1-p^s)\Big\}^{1-\gamma}}{(1-\theta)(1-p^b)} \tag{2.3.4}$$

Equations 2.3.1 and 2.3.2 are derived from big and small banks' optimization problem with respect to credit called lending curves, while equations 2.3.3 and 2.3.4 are rearranged from big and small banks' decisions on relationship services, called relationship curves. The first two equations indicate the optimal credit each bank will provide given the level of relationship services, while the other two point out the optimal relationship loan each bank will serve given the amount of credit issued. Proposition 2.3 dicusses how big and small banks interact each other.

Proposition 2.3 In equilibrium, big and small banks behave as following:

1. big bank borrows less than small bank: $x^{b^*} < x^{s^*}$

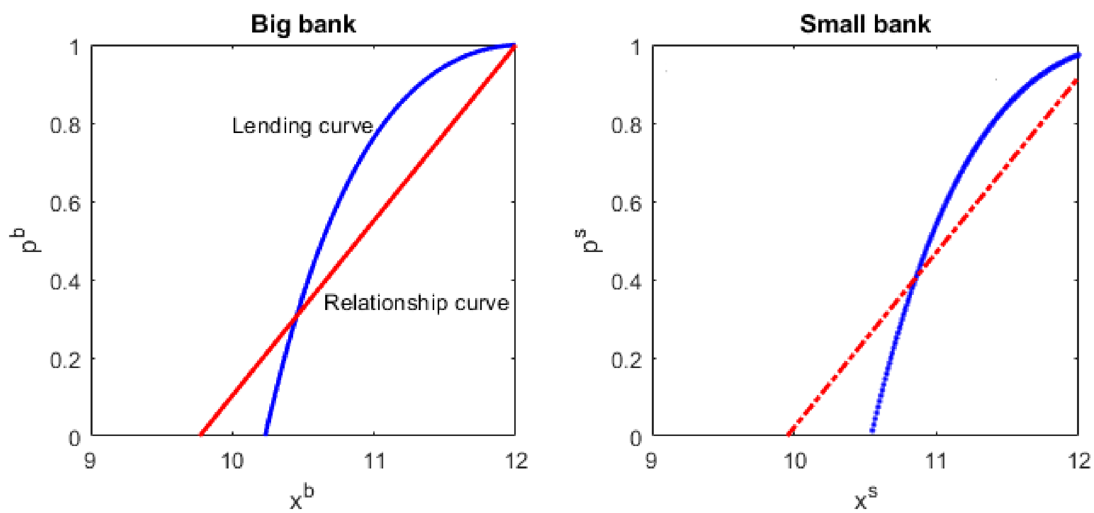
2. big bank lends more than small bank: $x^{b^*} + e_0 + \delta > x^{s^*} + e_0 - \delta$

3. big bank lends less relationship loan than small bank: $p^{b^*} < p^{s^*}$

Proof See appendix A.4.

Proposition 2.3 gives us three results. First, the big bank with larger endowment borrows less than the small one because it can use an endowment without incurring cost of paying deposit back to households[3]. Second, the big bank still lends more than the small one even if they borrow less since it uses the advantages of its size from endowment to lend more. The third implication is that the big bank with larger equity can afford in more risk-taking behavior by reducing the number of relationship services and paying fewer costs.

Figure 2.2: Banks' optimal choices



Note: The figure shows the optimal choice of each bank fixing the other bank's choice. Parameters used for numerical computation are: $e_0 = 0.5, \delta = 0.1, w = 10, A = 20, \beta = 3.7, \theta = 0.5, \gamma = 0.5, \alpha = 0.5$. LHS fixes $x^s = 4.8, p^s = 0.5$, while RHS fixes $x^b = 5.2, p^b = 0.5$.

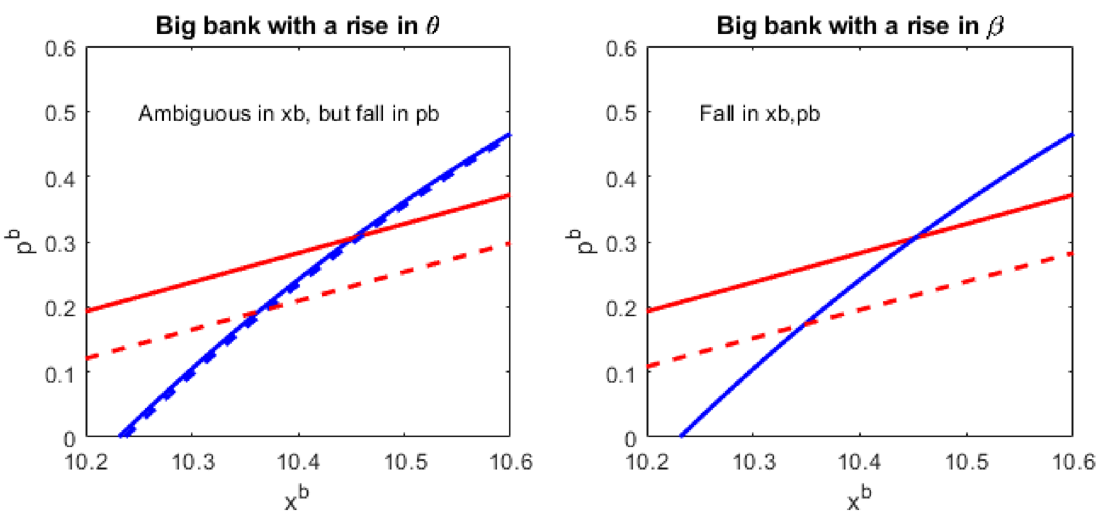
Figure 2.2 illustrates how big and small banks decide their optimal choices in credit and relationship service. The big bank's lending curve comes from equation 2.3.1. Its positive relationship implies the higher the relationship service, the more borrowing big bank should engage in lending

[3]During 2015-2019, even if Bank of America has lower level of total equity capital than JP Morgan Chase, the former accumulates more deposit than the latter. Such relationship (larger equity, lower deposit) breaks down when we compare the top-5 banks and the smaller ones.

more and enjoying more profit. The relationship curve from equation 2.3.3 indicates that the more borrowing, the more relationship service provided to make sure that their lending are successful. Big bank ends up with a lower level of deposit x^b compared with the smaller one.

This paper conducts comparative statics of each bank's optimal choices. Figure 2.3 shows how a bank responds to the change in the probability of success of the investment project (θ) and the cost of relationship service. A higher θ incentivizes bank to lend more as its tendency to obtain the fund back is higher, shifting the lending curve to the right. Still, its marginal benefit of relationship service is lower so its share of this type of loan falls, shifting the relationship curve to the right. The right-hand side of figure 2.3 has a rise in β. A bank decides to lower its relationship service due to its higher cost.

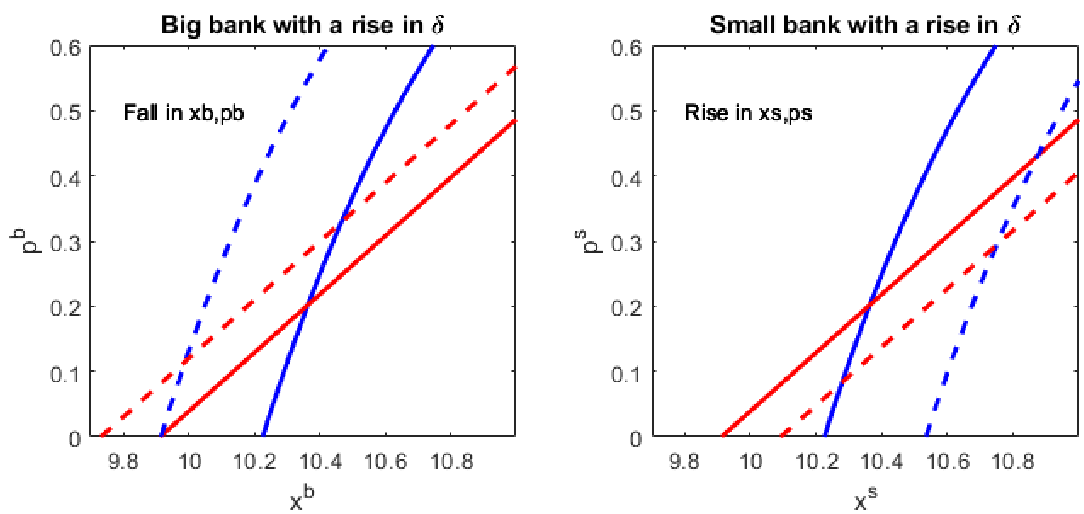
Figure 2.3: Bank's optimal choices after changes in θ and β



Note: Same set of parameters used in figure 2.2, and $\theta' = 0.505$, $\beta' = 3.75$

Figure 2.4 illustrates how big and small banks react when there is a change in their size difference δ. The small bank will borrow more to compensate for a loss in endowment and lend less relationship loan because its stake in investment project or its marginal benefit of relationship loan is lower. Nonetheless, the small bank choices on x^s and p^s are ambiguous, depending on which curve dominates. It borrows less since it has more endowment but lend more relationship loan since its marginal benefit is higher. The ambiguous implication in big bank's optimal choices similar to the small bank is drawn.

Figure 2.4: Bank's optimal choices after a change in δ



Note: Same set of parameters used in figure 2.2, and $\delta' = 0.2$

2.4 The equilibrium in capital and output

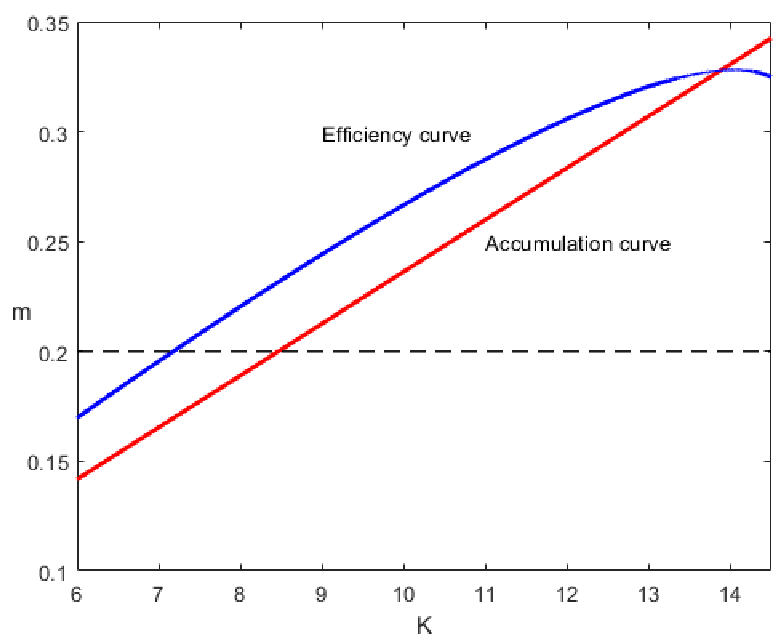
In this section, we study the general equilibrium of aggregate capital (K) and credit efficiency (m), and conduct comparative statics on how a change in size difference (δ) affects the total output. As we observe in the real world, big banks become larger and larger. Observing how higher δ leads to a change in output helps us understand what happens in the economy.

Figure 2.5 shows the equilibrium in capital and credit efficiency. The efficiency curve is solved numerically from the lending equations 2.3.1 and 2.3.2, pinning down the optimal level of credit efficiency given capital. A higher level of capital leads to higher credit efficiency. As the economy has more capital, the marginal product of capital will be lower and thus the interest rate on loan will fall. To compensate such loss in revenue, banks need to raise relationship loans to make investment project more successful.

The accumulation curve, on the other hand, is obtained from the relationship equations 2.3.3 and 2.3.4, expressing the optimal capital given credit efficiency. Capital and credit efficiency are also positively related. As credit efficiency is higher, banks find themselves profitable by lending more, and as a result, more capital is accumulated. The dashed line in the figure discloses the minimum value of credit efficiency when both banks decide to lend none of relationship services.

We can study the effect of a change in δ to the equilibrium capital, credit efficiency, and total output. First, consider how a change in δ affects the efficiency curve. Since the efficiency curve reveals the optimal m given capital K, a change in δ does not affect the amount of accumulated capital. In our setup, a rise in endowment of big bank means a fall in endowment of small bank. The total capital is transformed without depending on the change in the size difference: $K = m(x^b + x^s + 2e_0)$. Therefore, there is no change in the efficiency curve after a change in δ.

Figure 2.5: Equilibrium in K and m

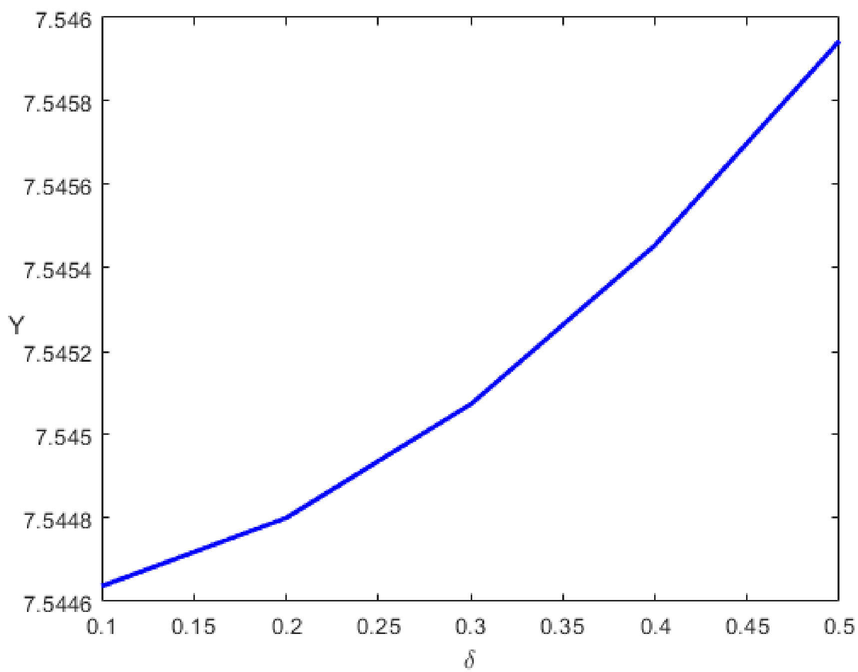


Note: Parameters used for numerical computation are: $e_0 = 5, \delta = 0, w = 15, A = 13, \beta = 10, \theta = 0.2, \gamma = 0.5, \alpha = 0.5$.

For the accumulation curve, it gives us an optimal value of capital given credit efficiency. A rise in δ affects the marginal benefit of relationship service (from equations 2.2.13 and 2.2.15). The big bank will then lend more of relationship loan. Higher relationship services mean the project has a higher tendency to succeed. Lending more of standard loans will guarantee a better return. Small bank will react the opposite because its marginal benefit in relationship service falls. The shift in accumulation curve will depend on which side dominates.

We then compute how a change in δ affects the total output. Figure 2.6 plots the change in δ on the horizontal axis and the total output on the vertical axis. Output ends up increasing after an increase in bank size because big bank dominates by lending more in both standard and relationship credits. The fixed cost in providing relationship loans plays a major role[4]. With such cost, a bigger bank can afford to provide more relationship loans to entrepreneurs without incurring additional cost per unit of credit. Therefore, a bank with efficient technology can give out more credit line and liquidity insurance to entrepreneurs and thus help foster economic growth.

Figure 2.6: Output after changes in δ



Note: Same set of parameters used in figure 2.5

2.5 Conclusion

Banks are heterogeneous in their size. This paper studies how big and small banks interact and how their size differences affects economic growth. We find that big bank with larger equity borrows less from households, lends more loan, and provide less relationship service to entrepreneurs

[4]However, consider another scenario when the cost of relationship services is linear for example. Its cost is higher and the bank might not be able to afford it. The result from a change in size to output will be different.

than the small one.

When a big bank gets larger and a small bank gets smaller, the former lends more in both standard and relationship loans while the latter lends less. Fixed cost in relationship services is the main reason why big bank engages in more financial activities. Bigger bank lend more credit using endowment and its marginal benefit of relationship loan is higher, encouraging itself to provide more relationship services. The credit efficiency is improved and generates more capital, which implies higher economic growth. If banks are efficient enough, it is willing to lend more and provide better services for their own profit. The economy benefits from its efficiency.

APPENDIX A

APPENDIX

A.1 Proof of Proposition 1.3.1

1. When the marginal product of land is greater than its cost of buying additional unit of land, borrower is then willing to purchase land to produce and consume at date 2 instead of date 1. R^B acted as a discount factor between two dates. $f'(0) \geq R^B q_1$. We can find the threshold of e^B such that $f'(0) \geq R^B q_1$ by solving $q_1(e^B)$ from demands for land from borrowers and lenders. Plug it into the above condition and obtain e^*:

$$e^* = \quad \bar{K}^2 + \frac{A^2\left[1+\beta^L(2-4R^B)+\beta^{L^2}R^B(-2+3R^B)\right]}{4\beta^{L^2}R^{B^2}} + \frac{A\left[\bar{K}+\beta^L(\bar{K}-k_0-2\bar{K}R^B)\right]}{\beta^L R^B}$$

2. Consider the relationship between land demand and price:

$$\frac{\partial k_1^B}{\partial q_1} = \frac{(k_0 - k_1^B)/q_1}{1 - \frac{\theta}{R^B q_1}f'(k_1^B)} \tag{A.1.1}$$

We can either have both nominator and denominator positive: $k_0 - k_1^B > 0$ and $1 - \frac{\theta}{R^B q_1}f'(k_1^B) > 0$ or negative: $k_0 - k_1^B < 0$ and $1 - \frac{\theta}{R^B q_1}f'(k_1^B) < 0$, then we have an upward sloping demand for land $\frac{\partial k_1^B}{\partial q_1} > 0$. First consider $k_0 - k_1^B$:

$$k_0 - k_1^B = \frac{-e^B - B}{q_1}$$

$$-e^B - B > 0 \Rightarrow k_0 - k_1^B > 0$$

$$e^B < -B = -\frac{\theta f(k_1^B)}{R^B} = \hat{e}_2$$

If the endowment is not enough to cover what borrower can borrow or $e^B < \hat{e}_2$, then borrower is forced to sell land. Next consider $1-\frac{\theta}{R^B q_1}f'(k_1^B)>0$:

$$
\begin{aligned}
1-\frac{\theta}{R^B q_1}f'(k_1^B)&>0\\
q_1(e^B)&>\frac{\theta f'(k_1^B)}{R^B}\\
&\Leftrightarrow e^B>\hat{e}_1
\end{aligned}
$$

Borrower must not sell land too much to drive down its price q_1 below the marginal benefit of borrowing $\frac{\theta f'(k_1^B)}{R^B}$. Otherwise, borrowers had better keep land to produce rather than sell it. We can again solve for a threshold $\hat{e}_1$ and $\hat{e}_2$.

Even though there is a possibility that we can have positive demand for land when both nominator and denominator are negative but there will be no feasible range of e^B that satisfy conditions of negative nominator and denominator because we would need $e^B<\hat{e}_1$ and $e^B>\hat{e}_2$.

The relationship between e^*, $\hat{e}_1$ and $\hat{e}_2$. We derive e^* from $f'(0)\geq R^B q_1(e^*)$ and $\hat{e}_1$ from $1-\frac{\theta}{R^B q_1}f'(k_1^B)>0\Leftrightarrow f'(k_0^B)<\frac{R^B}{\theta}q_1(\hat{e}_1)$ and $\hat{e}_2$ from $e^B<-\frac{\theta f(k_1^B)}{R^B}$. We can solve and obtain $\hat{e}_1$ and $\hat{e}_2$:

$$
\begin{aligned}
\hat{e}_1 = \ & \tfrac{1}{4(\beta^L R^B)^2}\Bigg(A^2\Big(\beta^{L^2}R^B(3R^B-4\theta)-2\beta^L(R^B-2\theta)\theta-\theta^2\Big)-4A\beta^L\Big((2k_0+\bar{K})\theta^2\\
&+\beta^L R^B(2\bar{K}R^B+2k_0\theta-3\bar{K}\theta)\Big)+4\beta^L\bar{K}\Big(2k_0\theta^2+\beta^L R^B(\bar{K}R^B+2k_0\theta-2\bar{K}\theta)\Big)\Bigg)
\end{aligned}
$$

$$
\begin{aligned}
\hat{e}_2 = \ & \tfrac{1}{2(R^B+2\beta^L R^B-\theta)^2}\Bigg[\beta^L\theta\Bigg(-3A^2R^B+3A^2\beta^L R^B+4Ak_0R^B-4A\beta^L k_0 R^B+4\beta^L k_0^2 R^B\\
&+2A\bar{K}R^B-8A\beta^L\bar{K}R^B-4k_0\bar{K}R^B+4\beta^L\bar{K}^2R^B+3A^2\theta-4Ak_0\theta-2A\bar{K}\theta+4k_0\bar{K}\theta\\
&-3A\Big(4\beta^L k_0(A-2\bar{K})R^B(R^B+2\beta^L R^B-\theta)+(A((\beta^L-1)R^B+\theta)-2\beta^L(k_0+\bar{K})R^B)^2\Big)^{1/2}\\
&+2k_0\Big(4\beta^L k_0(A-2\bar{K})R^B(R^B+2\beta^L R^B-\theta)+(A((\beta^L-1)R^B+\theta)-2\beta^L(k_0+\bar{K})R^B)^2\Big)^{1/2}\\
&+2\bar{K}\Big(4\beta^L k_0(A-2\bar{K})R^B(R^B+2\beta^L R^B-\theta)+(A((\beta^L-1)R^B+\theta)-2\beta^L(k_0+\bar{K})R^B)^2\Big)^{1/2}\Bigg)\Bigg]
\end{aligned}
$$

A.2 Proof of Proposition 1.4.1

For the first result, equation 1.3.4 suggests that when loan rate increases, it affects borrower's demand for land via binding collateral constraint because borrower will be able to get less loan and demand less land. The change in loan rate also causes the change in land price because of the change in land demand. We can think of that change of land price from loan rate as a movement along the curve when the demand curve shifts.

For the second result, consider bank's first-order necessary condition in t=1 as following:

$$
\begin{aligned}
R^{B,PC} &= C'(B) + R^P, \text{ and} \\
\frac{R^{B,O} - \Big(R^P + C'(B)\Big)}{R^{B,O}} &= -\frac{1}{n\epsilon} \\
\Rightarrow \frac{R^{B,O} - R^{B,PC}}{R^{B,O}} &= -\frac{1}{n\epsilon} = -\frac{1}{n\frac{\partial B}{\partial R^B}\frac{R^B}{B}}
\end{aligned}
$$

Apply implicit function theorem on collateral constraint in t=1.

$$
\begin{aligned}
B + \frac{\partial B}{\partial R^B} R^B &= \theta f'(k_1^B)\frac{\partial k_1^B}{R_1^B} \\
\frac{\partial B}{\partial R^B} &= \frac{\theta f'(k_1^B)\frac{\partial k_1^B}{\partial R^B} - B}{R^B}
\end{aligned}
$$

Since k_1^B is decreasing in R^B, we have $\frac{\partial k_1^B}{\partial R^B} < 0$ and then $\frac{\partial B}{\partial R^B} < 0$. Therefore, $R^{B,O} > R^{B,PC}$.

A.3 Proof of Proposition 1.4.2

The overall output produced in t=2 is:

$$
\begin{aligned}
y_2 &= f(k_1^B) + f(k_1^L) \\
&= Ak_1^B - (k_1^B)^2 + A(\bar{K} - k_1^B) - (\bar{K} - k_1^B)^2 \\
&= \bar{K}\Big(A - \bar{K} + 2k_1^B\Big)
\end{aligned}
$$

As long as $k_1^{B,PC} > k_1^{B,O}$, we have a larger output fall in oligopolistic case $y_2^O < y_2^{PC}$.

A.4 Proof of Proposition 2.3

1. From equations 2.2.10, we have

$$\begin{aligned} mR + (x^b + e_0 + \delta)m\frac{\partial R}{\partial x^b} &= r + x^b \frac{\partial r}{\partial x^b} \\ mR - r &= \left(\frac{x^b}{x}\right)\frac{r}{\epsilon_r} - \left(\frac{x^b + e_0 + \delta}{X + 2e_0}\right)\frac{mR}{\epsilon_R} \end{aligned}$$

Same for small bank: $mR - r = \left(\frac{x^s}{x}\right)\frac{r}{\epsilon_r} - \left(\frac{x^s+e_0-\delta}{X+2e_0}\right)\frac{mR}{\epsilon_R}$. We subtract between two equations and obtain:

$$\begin{aligned} \frac{x^b - x^s}{x} \cdot \frac{r}{\epsilon_r} &= \frac{x^b - x^s + 2\delta}{X + 2e_0}\frac{mR}{\epsilon_R} \\ \Leftrightarrow x^b - x^s &= \frac{2\delta}{X + 2e_0}\frac{mR}{\epsilon_R}\left(\frac{1}{\frac{r}{X\epsilon_r} - \frac{mR}{(X+2e_0)\epsilon_R}}\right) < 0 \end{aligned}$$

The RHS is negative because the interest elasticity of loan ϵ_R. Therefore, $x^b - x^s < 0$. That is, big bank borrows less than small bank.

2. We can write big and small bank's FONCs as following:

$$1 - (1-\theta)(1-p^b)(1-p^s) = \left\{ \frac{X^{1-\gamma}\left(\frac{W}{W-X}\right)^{\frac{1-\alpha}{\alpha}}}{A\gamma} \frac{\left(1 + \frac{1-\alpha}{\alpha}\frac{W}{W-X}\frac{x^b}{X}\right)}{(1-(1-\gamma)\frac{x^b+e_o+\delta}{X+2e_o})} \right\}^{\frac{1}{\gamma}}$$

$$1 - (1-\theta)(1-p^b)(1-p^s) = \left\{ \frac{X^{1-\gamma}\left(\frac{W}{W-X}\right)^{\frac{1-\alpha}{\alpha}}}{A\gamma} \frac{\left(1 + \frac{1-\alpha}{\alpha}\frac{W}{W-X}\frac{x^s}{X}\right)}{(1-(1-\gamma)\frac{x^s+e_o-\delta}{X+2e_o})} \right\}^{\frac{1}{\gamma}}$$

Use this property $\frac{A}{B} = \frac{C}{D} = \frac{A+C}{B+D} = \frac{A-C}{B-D} \Rightarrow$.

$$\frac{2 + \frac{1-\alpha}{\alpha}\frac{W}{W-X}}{1+\gamma} = \frac{\frac{x^b - x^s}{X}\frac{1-\alpha}{\alpha}\frac{W}{W-X}}{-A\gamma(1-\gamma)\frac{(x^b - x^s + 2\delta)}{X+2e_0}}$$

$$\underbrace{\frac{2 + \frac{1-\alpha}{\alpha}\frac{W}{W-X}}{1+\gamma}}_{+} = \frac{\overbrace{\left(\frac{x^b - x^s}{X}\right)}^{-}\overbrace{\left(\frac{1-\alpha}{\alpha}\frac{W}{W-X}\right)}^{+}}{\underbrace{\left(\frac{-(1-\gamma)A\gamma}{X+2e_0}\right)}_{-}\underbrace{(x^b - x^s + 2\delta)}_{\text{must be } +}}$$

We know from proposition 2.3 that $x^b - x^s < 0$. Then, $x^b - x^s + 2\delta$ must be positive so that the LHS is positive. Therefore, $(x^b + e_0 + \delta) - (x^s + e_0 - \delta)$ is positive. Big bank lends more credit.

3. From equation 2.2.13 and 2.2.15, we can write

$$\frac{x^b + e_o + \delta}{(X + 2e_o)^{1-\gamma}} = \frac{\beta}{\gamma^2 A}\frac{\left\{1 - (1-\theta)(1-p^b)(1-p^s)\right\}^{1-\gamma}}{(1-\theta)(1-p^s)}$$

$$\frac{x^s + e_o - \delta}{(X + 2e_o)^{1-\gamma}} = \frac{\beta}{\gamma^2 A}\frac{\left\{1 - (1-\theta)(1-p^b)(1-p^s)\right\}^{1-\gamma}}{(1-\theta)(1-p^b)}$$

$$\Rightarrow p^s - p^b = \underbrace{(1-p^b)(1-p^s)\frac{(1-\theta)\gamma^2 A}{\beta m^{1-\gamma}}}_{+}\left[\frac{x^b - x^s + 2\delta}{(X + 2e_0)^{1-\gamma}}\right]$$

We know from 2.3 that $x^b - x^s + 2\delta > 0$ and total credit $X + 2e_0 > 0$. Therefore, $p^s - p^b > 0$. Big bank lends less relationship loan than small bank.

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